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ARTICLE 250 - GROUNDING

A. General

250-1. Scope. This Article treats of protection of electric installations by grounding. Insulation, isolation, and guarding are suitable alternatives under certain conditions. See Section 110-17.

(a) Systems and Circuits. Circuits are grounded for the purpose of limiting the voltage upon the circuit which might otherwise occur through exposure to lightning or other voltages higher than that for which the circuit is designed; or to limit the maximum potential to ground due to normal voltage.

(b) Exposed Enclosures. Conductive materials enclosing electric conductors or equipment, or forming part of such equipment, are grounded for the purpose of preventing a potential above ground on these materials.

(c) Operation of Overcurrent Devices. Circuits and enclosures are grounded to facilitate overcurrent device operation in case of insulation failure or ground faults. See Section 110-10.

250-2. Other Articles. In other Articles, applying to particular cases of installation of conductors and equipment, there are requirements that are in addition to those of this Article or are modifications of them:

Section	Article
Appliances	422-16
Boat Harbor Wiring	555-6
Branch Circuits	210-5
	210-6
Cablebus	365-9
Communications Circuits	800
Community Antenna Television and Radio	

Distribution Systems	820-3
	820-8
	820-9
Conductors	310

Section	Article	
Conductors (Grounded)	200	
Cranes and Hoists	610	
Data Processing Systems		645-4
Elevators, Dumbwaiters, Escalators, and Moving Walks	620	
Fixed Electric Space Heating Equipment		424-
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Fixtures & Lighting Equipment		410-
91		
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92		
		410-
93		
		410-
94		
		410-
95		
		410-
96		
Flexible Cords		400-
13		
		400-
14		
Generators		445-8
Grounding Receptacles (Outlets)		210-7
		210-
21		
		210-
22		
Hazardous Locations	500-517	
Inductive and Dielectric Heat Generating Equipment	665	
Less Than 50 V	720	
Lighting Fixtures	410	
Metalworking Machine Tools	670	
Mobile Homes	550	
Motion Picture Studios		530-
19		
		530-
66		
Motors and Controllers	430	
Organs	650	
Outlet, Switch and Junction Boxes & Fittings		370-4
		370-
15		
Radio and Television	810	
Receptacles & Attachment Plugs		410-
55		
		410-
56		
Remote Control Circuits		725-
21		

Services	230	
Service Equipment		230-
63		
Signs and Outline Lighting	600	
Sound Recording Equipment		640-4
Swimming Pools	680	
Switchboards		384-
11		
Switches		380-1
		380-
12		
Theaters & Assembly Halls		520-
81		
Transformers		450-8
Travel Trailers	551	
X-ray Equipment	660	

B. Circuit and System Grounding

250-3. Two-Wire Direct-Current Systems. Two-wire direct-current systems supplying interior wiring, and operating at not more than 300 volts between conductors, shall be grounded, unless such system is used for supplying industrial equipment in limited areas and the circuit is equipped with a ground detector.

It is recommended that 2-wire direct-current systems operating at more than 300 volts between conductors be grounded when a neutral point can be established such that the maximum difference of potential between the neutral point and any other point on the system does not exceed 300 volts. It is recommended that 2-wire direct-current systems be not grounded when the voltage to ground of either conductor would exceed 300 volts after grounding.

250-4. Three-Wire Direct-Current Systems. The neutral conductor of all 3-wire direct-current systems supplying interior wiring shall be grounded.

250-5. Alternating-Current Systems. Secondary alternating-current systems supplying interior wiring, and interior alternating-current wiring systems, except those covered in Sections 250-6, 250-7 and 250-8, shall be grounded when they can be so grounded that the maximum voltage to ground does not exceed 150 volts. Where a service conductor is uninsulated in accordance with Section 230-4, the system shall be grounded.

It is recommended that alternating-current systems be grounded as provided in this article when the voltage to ground does not exceed 300 volts. Higher voltage systems may be grounded.

It is also recommended that ungrounded systems supplying industrial equipment and operating at more than 150 volts and less than 600 volts be equipped with ground detectors.

250-6. Furnace Circuits. Electric furnace circuits need not be grounded.

250-7. Electric Crane Circuits. Circuits for electric cranes operating over combustible fibers in Class III hazardous locations shall not be grounded. See Section 503-13.

250-8. Circuits of Less than 50 Volts. Circuits of less than 50 volts need not be grounded, except as follows:

(a) Where supplied by transformers from systems of more than 150 volts to ground, except as provided in Section 250-45(d).

(b) Where supplied by transformers from ungrounded systems.

(c) Where run overhead outside buildings.

C. Location of Grounding Connections

250-21. Current Over Grounding Conductors. The grounding of wiring systems, circuits, arresters, cable armor, conduit, or other metal raceways as a protective measure shall be so arranged that there will be no objectionable passage of current over the grounding conductors. The temporary currents set up under accidental conditions, while the grounding conductors are performing their intended protective functions, are not to be considered as objectionable. Where an objectionable flow of current occurs over a grounding conductor, due to the use of multiple grounds, (1) one or more of such grounds shall be abandoned, or (2) their location shall be changed, or (3) the continuity of the conductor between the grounding connections shall be suitably interrupted, or (4) other means satisfactory to the authority having jurisdiction shall be taken to limit the current.

250-22. Grounding Connection for Direct-Current Systems. Direct-current systems which are to be grounded shall have the grounding connection made at one or more supply stations but not at individual services nor elsewhere on interior wiring.

250-23. Grounding Connections for Alternating-Current Systems.

(a) Secondary alternating-current circuits which are to be grounded shall have a connection to a grounding electrode at each service, except as provided for in Section 250-21. The connection shall be made on the supply side of the service disconnecting means. Each secondary distribution system which is grounded shall have at least one additional grounding conductor connection to a grounding electrode at the transformer or elsewhere. No connection to a grounding electrode shall be made to the grounded circuit conductor on the load side of the service disconnecting means. See Section 250-24 for two or more buildings supplied by a single service and Section 250-26 for separately derived systems.

(b) Where the secondary system is grounded at any point, the grounded conductor shall be run to each service. This conductor shall be not smaller than the required common main grounding conductor specified in Table 250-94(a) and, in addition, for service phase conductors larger than 1100 MCM the grounded conductor shall be not smaller than 12 1/2 per cent of the area of the largest phase conductor.

250-24. Two or More Buildings Supplied by a Single Service. Where more than one building is supplied by the same service, the grounded circuit conductor of the wiring system of any building utilizing one branch circuit supplied from such service may be connected to a grounding electrode at such building, and in the case of any building housing equipment required to be grounded or utilizing two or more branch circuits supplied from such service,

and in the case of a building housing live stock, shall be so connected.

250-25. Conductor to be Grounded. For alternating-current interior wiring systems the conductor to be grounded shall be as follows:

- (a) Single-phase, 2-wire: the identified conductor;
- (b) Single-phase, 3-wire: the identified neutral conductor;
- (c) Multiphase systems having one wire common to all phases: the identified common conductor;
- (d) Multiphase systems having one phase grounded: the identified common conductor;
- (e) Multiphase system in which one phase grounded: the identified neutral conductor. One phase only can be grounded.

See Article 200.

The identified conductor is commonly known as "the white wire."

250-26. Separately Derived Systems. For an interior wiring system which is required by Section 250-5 to be grounded, the phase conductors of which are not electrically connected to another supply system, a common main grounding conductor shall be connected at the transformer, generator or other source of supply or at the switchboard on the supply side of the disconnecting means of the system.

D. Enclosure Grounding

250-32. Service Conductor Enclosure. Service raceways, service cable sheaths or armoring, when of metal, shall be grounded.

250-33. Other Conductor Enclosures. Metal enclosures for conductors shall be grounded, except they need not be grounded in runs of less than 25 feet which are free from probable contact with ground, grounded metal, metal lath or conductive thermal insulation and which, where within reach from grounded surfaces, are guarded against contact by persons.

250-34. Spacing from Lightning Rods. Metal enclosures of conductors shall, wherever practicable, be kept at least 6 feet away from lightning rod conductors. When it is not practicable to secure 6 feet separation, they shall be bonded together.

E. Equipment Grounding

250-42. Fixed Equipment - General. Under any of the following conditions, exposed, noncurrent-carrying metal parts of fixed equipment, which are liable to become energized, shall be grounded:

- (a) Where equipment is supply by means of metal-clad wiring;
- (b) Where equipment is located in a wet location and is not isolated;
- (c) Where equipment is located within reach of a person who can make contact with any grounded surface or object;
- (d) Where equipment is located within reach of a person standing on the ground;
- (e) Where equipment is in a hazardous location; see Articles 500-517 inclusive;
- (f) Where equipment is in electrical contact with metal or metal lath;
- (g) Where equipment operates with any terminal at more than 150 volts to ground, except as follows:
 - (1) Enclosures for switches or circuit breakers where accessible to qualified persons only;
 - (2) Metal frames of electrically heated devices, exempted by special permission, in which case the frames shall be permanently and effectively insulated from ground;
 - (3) Transformers mounted on wooden poles at a height of more than 8 feet from the ground.

250-43. Fixed Equipment - Specific. Exposed, noncurrent-carrying metal parts of the following kinds of equipment, regardless of voltage, shall be grounded:

- (a) Frames of motors as specified in Section 430-142;
- (b) Controller cases for motors, except lined covers of snap switches;
- (c) Electric equipment of elevators and cranes;
- (d) Electric equipment in garages, theaters and motion picture studios, except pendant lampholders on circuits of not more than 150 volts to ground;
- (e) Motion-picture projection equipment.

(f) Electric signs and associated equipment, unless these are inaccessible to unauthorized persons and are also insulated from ground and from other conductive objects;

(g) Generator and motor frames in an electrically operated organ, unless the generator is effectively insulated both from ground and from the motor driving it;

(h) Switchboard frames and structures supporting switching equipment, except that frames of direct-current, single-polarity switchboards need not be grounded where effectively insulated;

(i) Equipment supplied by Class 1 and Class 2 remote control and signaling circuits where Part B of this article requires those circuits to be grounded.

250-44. Nonelectrical Equipment. The following metal parts shall be grounded:

(a) Frames and tracks of electrically operated cranes;

(b) The metal frame of a nonelectrically driven elevator car to which electric conductors are attached;

(c) Hand-operated metal shifting ropes or cables of electric elevators;

(d) Metal enclosures such as partitions, grill work, etc., around equipment carrying voltages in excess of 750 volts between conductors, unless in substations or vaults under the sole control of the supply company.

Where extensive metal in or on buildings may become energized and is subject to personal contact, adequate bonding and grounding will provide additional safety.

250-45. Equipment Connected by Cord and Plug. Under any of the following conditions, exposed noncurrent-carrying metal parts of cord and plug connected equipment, which are liable to become energized, shall be grounded:

(a) In hazardous locations (see Articles 500 to 517);

(b) When operated at more than 150 volts to ground, except:

(1) Motors, where guarded;

(2) Metal frames of electrically heated appliances exempted by Section 422-16.

(c) In residential occupancies, (1) refrigerators, freezers, air conditioners, and (2) clothes-washing, clothes-drying and dish-washing machines, sump pumps and (3) portable, hand held,

motor operated tools and appliances of the following types: drills, hedge clippers, lawn mowers, wet scrubbers, sanders and saws.

Exception: Portable tools and appliances covered by Section 250-45(c) (3), protected by an approved system of double insulation, or its equivalent, need not be grounded. Where such an approved system is employed the equipment shall be distinctively marked.

Portable tools or appliances not provided with special insulating or grounding protection are not intended to be used in damp, wet or conductive locations.

(d) In other than residential occupancies, (1) refrigerators, freezers, air conditioners, and (2) clothes-washing, clothes-drying and dish-washing machines, sump pumps and (3) portable, hand held, motor operated tools and appliances of the following types: drills, hedge clippers, lawn mowers, wet scrubbers, sanders and saws, and (4) cord and plug connected appliances using in damp or wet locations, or by persons standing on the ground or on metal floors or working inside of metal tanks or boilers, and (5) portable tools which are likely to be used in wet and conductive locations.

Exception No. 1: Portable tools which are likely to be used in wet and conductive locations need not be grounded where supplied through an insulating transformer with ungrounded secondary of not over 50 volts.

Exception No. 2: Portable tools covered by Sections 250-45(d) (3), (4) and (5) and appliances covered by Section 250-45(d) (3), protected by an approved system of double insulation, or its equivalent, need not be grounded. Where such an approved system is employed, the equipment shall be distinctively marked. Where conditions of maintenance and supervision assure that proper grounding of tools or appliances will be maintained (as, for example, on some factory production lines) it is recommended that grounded type tools and appliances be used.

It is recommended that the frames of all portable motors which operate at more than 50 volts to ground be grounded.

250-46. Spacing from Lightning Rods. Metal frames and enclosures of electric equipment shall, wherever practicable, be kept at least 6 feet away from lightning rod conductors. Where it is not practicable to secure 6 feet separation, they shall be bonded together. See Sections 250-34 and 250-86.

F. Methods of Grounding

250-51. Effective Grounding. The path to ground from circuits, equipment, and conductor enclosures shall (1) be permanent and

continuous and (2) shall have ample carrying capacity to conduct safely any currents liable to be imposed on it, and (3) shall have impedance sufficiently low to limit the potential above ground and to facilitate the operating of the overcurrent devices in the circuit.

250-52. Location of System Ground Connection. The grounding conductor may be connected to the grounded conductor of the wiring system at any convenient point on the premises on the supply side of the service disconnecting means.

It is recommended that high capacity services have the grounding conductor connected to the grounded conductor of the system within the service entrance equipment enclosure.

250.53. Common Use of Grounding Conductor. The grounding conductor of a wiring system shall also be used for grounding equipment, conduit and other metal raceways or enclosures for conductors, including service conduit or cable sheath and service equipment.

Exception: The grounding connection as covered in the exception in Section 210-7 may be made to a grounded cold water pipe near the equipment.

250-54. Common Grounding Electrode. Where the alternating-current system is connected to a grounding electrode in or at a building as specified in Sections 250-23 and 250-24, the same electrode shall be used to ground conductor enclosures and equipment in or on that building.

250.55. Underground Service Cable. Where served from a continuous underground metal-sheathed cable system, the sheath or armor of underground service cable metallically connected to the underground system, or underground service conduit containing a metal-sheathed cable bonded to the underground system, need not be grounded at the building and may be insulated from the interior conduit or piping.

250-56. Short Sections of Raceway. Isolated sections of metal raceway or cable armor, where required to be grounded, shall preferably be grounded by connecting to other grounded raceway or armor, but may be grounded in accordance with Section 250-57.

250-57. Fixed Equipment.

(a) Metal boxes, cabinets and fittings, or noncurrent-carrying metal parts of other fixed equipment where metallically connected to grounded flexible metal raceways and fittings both approved for grounding purposes; the grounded armor of Types AC, ALS, and MI cables; or grounded rigid metal raceways are considered to be grounded by such connections.

(b) They may also be grounded in one of the following ways:

(1) By a grounding conductor run with circuit conductors; this conductor may be uninsulated, but where it is provided with an individual covering, the covering shall be finished a continuous green color or a continuous green color with one or more yellow stripes.

(2) By a grounding conductor in the supply cord, when cord connected as permitted in Section 400-3;

(3) By special permission, other means for grounding fixed equipment may be used.

250-58. Equipment on Structural Metal.

(a) Electric equipment secured to and in contact with the grounded structural metal frame of a building shall be deemed to be grounded.

(b) Metal car frames supported by metal hoisting cables attached to or running over sheaves or drums of elevator machines shall be deemed to be grounded where the machine is grounded in accordance with this Code.

250-59. Portable and/or Cord and Plug-Connected Equipment. The non-current carrying metal parts of cord and plug-connected equipment required to be grounded may be grounded in any one of the following ways:

(a) By means of the metal enclosure of the conductors feeding such equipment, provided an approved grounding-type attachment plug is used, one fixed contacting member being for the purpose of grounding the metal enclosure, and provided, further, that the metal enclosure of the conductors is attached to the attachment plug and to the equipment by connectors approved for the purpose;

Exception: The grounding contacting member of grounding type attachment plugs on the power supply cord of portable hand-held, hand guided or hand-supported tools or appliances may be of the movable self-restoring type.

Attachment plug caps are not intended to be used as terminations for metal-clad or flexible metal conduit.

(b) By means of a grounding conductor run with the power supply conductors in a cable assembly or flexible cord that is properly terminated in an approved grounding-type attachment plug having a fixed grounding contacting member. The grounding conductor in a cable assembly may be uninsulated; but where an individual covering is provided for such conductors it shall be finished a continuous green color or a continuous green color with one or more yellow stripes.

Exception: The grounding contacting member of grounding type attachment plugs on the power supply cord or portable tools or portable appliances may be of the movable self-restoring type.

(c) A separate flexible wire or strap, insulated or bare, protected as well as practicable against physical damage may be used only by special permission except where a part of an approved portable equipment.

250-60. Frames of Electric Ranges and Electric Clothes Dryers.

Frames of electric ranges and electric clothes dryers shall be grounded by any of the means provided for in Sections 250-57 and 250-59; or, where served by a 120/240 volt, single phase, three-wire circuit or a 120/208 volt circuit derived from a three-phase, four-wire supply, they may be grounded by connection to the grounded circuit conductors, provided the grounded circuit conductors are not smaller than No. 10 AWG. Where service-entrance cable having an uninsulated neutral conductor is used, the branch circuit shall originate at the service-entrance equipment. The frames of wall-mounted ovens and counter-mounted cooking units shall be grounded and may be grounded in the same manner as electric ranges. Grounding contacts of receptacles furnished as a part of equipment grounded to the neutral circuit conductor shall be bonded to the equipment which is so grounded.

It is recommended that all branch circuits supplying equipment which is grounded to the grounded circuit conductor originate at the service equipment.

250-61. Grounding Equipment to Circuit Conductor. The grounded service conductor on the supply side of the service disconnecting means may be used for grounding meter housing and service equipment and metallic enclosures and guards. The grounded circuit conductor on the load side of the service disconnecting means shall not be used for grounding equipment, cable armor, or metal raceways except as provided in Section 250-57 (b) (4), and in Section 250-60.

G. Bonding

250-71. Bonding at Service Equipment. The electrical continuity of the grounding circuit for the following equipment and enclosures shall be assured by one of the means given in Section 240-72.

(a) The service raceways or service cable armor or sheath, except as provided in Section 230-63(b) and Section 250-55;

(b) All service equipment enclosures containing service entrance conductors, including meter fittings, boxes or the like, interposed in the service raceway or armor;

(c) Any conduit or armor which forms part of the grounding conductor to the service raceway.

250-72. Continuity at Service Equipment. Electrical continuity at service equipment shall be assured by one of the following means:

(a) Bonding equipment to the grounded service conductor in a manner provided in Section 250-113.

(b) Threaded couplings and threaded bosses on enclosures with joints shall be made up wrenchtight where rigid conduit is involved.

(c) Threadless couplings made up tight for rigid metal conduit and electrical metallic tubing.

(d) Bonding jumpers meeting the other requirements of this article. Bonding jumpers shall be used around concentric or eccentric knock-outs which are punched or otherwise formed so as to impair the electrical connection to ground.

(e) Other devices (not locknuts and bushings) approved for the purpose.

230-73. Metal Armor or Tape of Service Cable. With service cable having an uninsulated grounded service conductor in continuous electrical contact with its metallic armor or tape, the metal covering is considered to be adequately grounded.

250-74. Bonding at Grounding-Type Receptacles. Grounding continuity between a grounded outlet box and the grounding circuit of the receptacle shall be established by means of a bonding jumper between the outlet box and the receptacle grounding terminal.

Exception No. 1: When the box is surface-mounted, direct metal-to-metal contact between the device yoke and the box may be used to establish the grounding circuit.

Exception No. 2: Contact devices or yokes designed and approved for the purpose may be used in conjunction with the supporting screws to establish the grounding circuit between the device yoke and flush-type boxes installed in walls.

250-75. Continuity at Other Enclosures. The electrical continuity of metallic raceway systems and cable armor that are to serve as grounding conductors shall be assured. At points where raceway or armor connects to metal enclosures, any nonconducting coating which might interrupt such continuity shall be removed unless fittings are used which are so designed that such removal is unnecessary.

250-76. Voltages Exceeding 250 Volts. The electrical continuity of metal raceway or metal sheathed cable which contains any conductor other than service entrance conductors of more than 250 volts to ground shall be assured by one of the methods specified in Sections 250-72(b), (c), (d), and (e), or by one of the following methods:

(a) Threadless fittings, made up tight, with conduit or metal-clad cable;

(b) Two locknuts, one inside and one outside of boxes and cabinets.

250-77. Loosely Jointed Metal Raceways. Expansion joints and telescoping sections of raceways shall be made electrically continuous by bonding jumpers or other approved means. Metal trough raceways used in connection with sound recording and reproducing, made up in sections, shall contain a grounding conductor to which each section shall be bonded.

250-78. Hazardous Locations. In hazardous locations, regardless of the voltage involved, the electrical continuity of metallic raceway, boxes and the like, shall be assured by one of the methods specified in Sections 250-72(b), (c), (d), and (e).

250-79. Bonding Jumpers. Bonding jumpers shall conform to the following:

(a) **Material and Size.** Bonding jumpers shall be of copper or other corrosion-resistant material. The size shall be as required by Section 250-94 for services and as required by Section 250-95 for raceways and equipment on the load side of the service protective equipment.

(b) **Attachment.** Bonding jumpers shall be attached to cabinets and the like in a manner provided in Section 250-113; where used between grounding electrodes or around water meters and the like, they shall be attached in a manner provided for in Section 250-115.

H. Grounding Electrodes

250-81. Water Pipe. A metallic underground water piping system, either local or supplying a community, shall always be used as the grounding electrode where such a piping system is available. Where the buried portion of the metallic piping system is less than ten feet (including well casings bonded to the piping system) or there is some likelihood of the piping system being disconnected or isolated through the use of nonmetallic piping or insulated couplings, the piping system shall be supplemented by one or more of the grounding electrodes recognized in Sections 250-82 and 250-83. The interior metallic cold water piping system shall always be bonded to the one or more grounding electrodes.

Expanding use of nonmetallic piping for water systems and insulating couplings on metallic water systems makes it more important that water piping within a building be adequately grounded without depending on connections to an outside piping system. The interior piping system should be electrically continuous. Bonding to gas, sewer, hot water piping and metallic air ducts within the premises will provide additional safety.

250-82. Other Available Electrodes. Where a water system as described in Section 250-81 is not available, the grounding connection may be made to any of the following:

(a) The metal frame of the building, where effectively grounded.

(b) Where permitted, a continuous metallic underground gas piping system. Underground gas service piping shall not be used as a grounding electrode except when it is electrically continuous uncoated metallic piping and its use as a grounding electrode is acceptable both to the serving gas supplier and to the authority having jurisdiction, since gas piping systems are often constructed with insulating bushings or joints, or are of coated or nonmetallic piping.

(c) Other local metallic underground systems, such as piping, tanks, and the like.

250-83. Made Electrodes. Where electrodes described in Sections 250-81 and 250-82 are not available, the grounding electrode shall consist of a driven pipe, driven rod, buried Plate or other device approved for the purpose and conforming to the following requirements:

(a) **Concrete Encased Electrodes.** Not less than twenty feet of bare copper conductor of a size specified in Table 250-94(a), and in no case smaller than No. 4, encased along the bottom of a concrete foundation footing which is in direct contact with the earth.

(b) **Plate Electrodes.** Each plate electrode shall present no less than 2 square feet of surface to exterior soil. Electrodes of iron, or steel plates shall be at least 1/4 inch in thickness. Electrodes of nonferrous metal shall be at least 0.06 inch in thickness.

(c) **Pipe Electrodes.** Electrodes of pipe or conduit shall be not smaller than of the 3/4-inch trade size and, where of iron or steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

(d) **Rod Electrodes.** Electrodes of rods of steel or iron shall be at least 5/8 inch in diameter. Approval rods of nonferrous materials or their approved equivalent used for electrodes shall be not less than 1/2 inch in diameter.

(e) Installation. Electrodes should, as far as practicable, be imbedded below permanent moisture level. Except where rock bottom is encountered, pipes or rods shall be driven to a depth of at least 8 feet regardless of size or number of electrodes used. Pipes or rods when less than standard commercial length shall preferably be of one piece. Such pipes or rods shall have clean metal surfaces and shall not be covered with paint, enamel or other poorly conducting materials. Where rock bottom is encountered at a depth of less than 4 feet, electrodes shall be buried in a horizontal trench, and where pipes or rods are used as the electrode they shall comply with Section 250-83 (b and c) and shall not be less than 8 feet in length. Each electrode shall be separated at least 6 feet from any other electrode, including those used for signal circuits, radio, lightning rods, or any other purpose.

250-84. Resistance. Made electrodes shall, where practicable, have a resistance to ground not to exceed 25 ohms. Where the resistance is not as low as 25 ohms, two or more electrodes connected in parallel shall be used.

Continuous metallic underground water or gas piping systems in general have a resistance to ground of less than 3 ohms. Metal frames of buildings and local metallic underground piping systems, metal well casings, and the like, have, in general, a resistance substantially below 25 ohms. It is recommended that in locations where it is necessary to use made electrodes for grounding interior wiring systems, additional grounds, such as connections to a system ground conductor be placed on the distribution circuit. It is also recommended that single electrode grounds when installed, and periodically afterwards, be tested for resistance.

250-85. Railway Tracks. Rails or other grounded conductors of electric railway circuits shall not be used (a) as a ground for other than railway lightning arresters and railway equipment, conduit, armored cable, metal raceway, and the like, where other effective grounds are available; and (b) in no case shall such rails or other grounded conductors of railway circuits be used for grounding interior wiring systems other than those supplied from the railway circuit itself

250-86. Use of Lightning Rods. Lightning rod conductors and driven pipes, rods or other made electrodes used for grounding lightning rods, shall not be used in lieu of the made grounding electrodes required by this Article for grounding wiring systems and equipment. The foregoing provision shall not be taken to forbid the bonding together of the several made electrodes that are respectively provided for electric wiring systems and equipment, for communication systems, and for lightning protection. See Section 800-31 (b) (5).

It is recommended that all separate electrodes be bonded together to limit potential differences between them and between their associated wiring systems.

J. Grounding Conductors

250-91. Material. The material for the grounding conductors shall be as follows:

(a) For System or Common Grounding Conductor. The grounding conductor of a wiring system shall be of copper or other corrosion-resistant material. The conductor may be solid or stranded, insulated or bare. Except in cases of bus-bars, the grounding conductor shall be without joint or splice throughout its length. Where the grounding conductor is not of copper, its electrical resistance per linear foot shall not exceed that of the allowable copper conductor for such a purpose.

(b) For Conductor Enclosures and Equipment Only. The grounding conductor for equipment and for conduit and other metal raceways or enclosures for conductors may be a conductor of copper or other corrosion-resistant material, stranded or solid, insulated or bare, a bus bar or a rigid metal conduit, electrical metallic tubing or flexible metal conduit and fittings both approved for grounding purposes, the armor of Type AC metal-clad cable, Types MI and ALS cable. Under conditions favorable to corrosion, a suitable corrosion-resistant material shall be used. All bolted and threaded connections at joints and fittings shall be made tight by the use of suitable tools.

205.92. Installation. Grounding conductors shall be installed as follows:

(a) System or Common Grounding Conductor. A grounding conductor, No. 4 or larger, may be attached to the surface on which it is carried without the use of knobs, tubes or insulators. It need not have protection unless exposed to severe physical damage. A No. 6 grounding conductor, which is free from exposure to physical damage, may be run along the surface of the building construction without metal covering or protection, where it is rigidly stapled to the construction; otherwise, it shall be in conduit, electrical metallic tubing or cable armor. Grounding conductors smaller than No. 6 shall be in conduit, electrical metallic tubing or cable armor. Metallic enclosures for grounding conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode, and shall be securely fastened to the ground clamp or fitting. Metallic enclosures which are not physically continuous from cabinet or equipment to the grounding electrode can be made electrically continuous by bonding each end to the grounding conductor. Where rigid metallic conduit or steel pipe is used as protection for a grounding conductor, the installation shall comply with the requirement of Article 346; where electrical

metallic tubing is used, the installation shall comply with the requirements of Article 348. Aluminum grounding conductors shall not be used where in direct contact with masonry or the earth or where subject to corrosive conditions. Where used outside, aluminum grounding conductors shall not be installed within 18 inches of the earth.

(b) Conductor Enclosures and Equipment Only. A grounding conductor for conductor enclosures and equipment only shall meet the requirements of Section 250-92 (a), except that where smaller than No. 6 as permitted by Section 250-95, it need not be armored or installed in a raceway where run through the hollow spaces of a wall or partition or otherwise run so as to be not subject to physical damage.

250-93. Direct Current Systems. The ampacity of the grounding conductor for a direct-current supply system or generator shall be not less than that of the largest conductor supplied by the system, except that where the grounded circuit conductor is a neutral derived from a balancer winding or a balancer set protected in accordance with requirements of Section 445-4(d), the size of the grounding conductor shall not be less than that of the neutral conductor. The grounding conductor shall in no case be smaller than No. 8 copper.

250-94. Alternating Current Systems.

(a) Service and Common Grounding Conductor for Grounded Systems. Where the wiring system is grounded, the size of the grounding conductor for an alternating current system or for a common grounding conductor shall not be less than is given in Table 250-94 (a), except that where connected to made electrodes (as in Section 250-83), that portion of the grounding conductor which is the sole connection between the grounding electrode and the grounded system conductor need not be larger than No. 6 copper wire or its equivalent in ampacity.

(b) Service Equipment Grounding Conductor for Ungrounded Systems. Where the wiring system is ungrounded, the size of a grounding conductor for a service raceway, for the metal sheath or armor of a service cable, and for service equipment shall not be less than is given in Table 250-94(b), except that where connected to made electrodes (as in Section 250-83) that portion of the grounding conductor which is the sole connection between the grounding electrode and the service equipment need not be larger than No. 6 copper wire or its equivalent in ampacity.

250-95. Size of Equipment Grounding Conductors. The size of copper or aluminum equipment grounding conductors shall be not less than given in Table 250-95. For permissible use of the enclosing raceway see Sections 250-57(a) and 250-91(b).

Exception: A conductor not smaller than No. 18 AWG copper which is part of an approved cord assembly may be used to ground cord connected equipment protected at not more than 20 amperes.

Table 250-94(a)
Service and Common Main Grounding Conductor for Grounded Systems

Size of Largest Service Conductor or Equivalent for Multiple Conductors		Size of Grounding Conductor	
Copper	Aluminum	Copper	Aluminum*
2 or smaller	0 or smaller	8	6
1 or smaller	2/9 or 3/0	6	4
2/0 or 3/0	4/0 or 250 MCM	4	2
Over 3/0 to 350 MCM	Over 250 MCM to 500 MCM	2	0
Over 350 MCM to 600 MCM	Over 500 MCM to 900 MCM	0	3/0
Over 600 MCM to 1100 MCM	Over 900 MCM to 1750 MCM	2/0	4/0
Over 1100 MCM	Over 1750 MCM	3/0	250 MCM

*See installation restrictions in Section 250-92(a).

See Section 250-23 (b).

Table 250-94(b)
Service Equipment Grounding Conductor for Ungrounded Systems

Size of Largest Service Conductor or Equivalent for Multiple Conductors		Size of Grounding Conductor			
Copper	Aluminum	Copper	Aluminum	Conduit or Pipe	Metallic Tubing
2 or smaller	0 or smaller	8	6	1/2	1/2
1 or 0	2/0 or 3/0	6	4	1/2	1
2/0 or 3/0	4/0 or 250 MCM	4	2	3/4	1 1/4
Over 3/0 to 350 MCM	Over 250 MCM to 500 MCM	2	0	3/4	1 1/4
Over 350 MCM to 600 MCM	Over 500 MCM to 900 MCM	0	3/0	1	2
Over 600 MCM to 1100 MCM	Over 900 MCM to 1750 MCM	2/0	4/0	1	2
Over 1100 MCM	Over 1750 MCM	3/0	250 MCM	1	2

250-97. Outline Lighting. Isolated noncurrent carrying metal parts of outline lighting systems may be bonded together by a No. 14 conductor protected from physical damage, where a conductor complying with Section 250-95 is used to ground the group.

250-98. Common Raceway. A grounding conductor may be run in the same metal raceway with other conductors of the system to which it is connected.

250-99. Continuity. No automatic cutout or switch shall be placed in the grounding conductor of an interior wiring system unless the opening of the cutout or switch disconnects all sources of energy.

K. Grounding Conductor Connections

250-111. To Raceway or Cable Armor. The point of connection of the grounding conductor to interior metal raceways, cable armor and the like shall be as near as practicable to the source of supply and shall be so chosen that no raceway or cable armor is grounded through a run of smaller size than is called for in Section 250-95.

250-112. To Electrode. The grounding connection to the electrode shall be located as follows:

(a) **To Water Pipes.** System or common grounding conductors shall be attached to a water piping system on the street side of the water meter or on a cold water pipe as near as practicable to the water service entrance to the building. Where the source of the water supply is from a driven well in the basement of the premises, the connection shall be made as near as practicable to the well. Where practicable, the point of attachment shall be accessible. Where the point of attachment is not on the street side of the water meter, the water piping system shall be made electrically continuous by bonding together all parts between the attachment and the street side of the water meter or the pipe entrance which contain insulating sections or are liable to become disconnected, as at meters, valves and service unions.

**Table 250-95. Size of Equipment Grounding Conductors for
Grounding Interior Raceway and Equipment**

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size	
	Copper Wire No.	Aluminum Wire No.*
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
400	3	1
600	1	2/0
800	0	3/0
1000	2/0	4/0
1200	3/0	250 MCM
1600	4/0	350 MCM
2000	250 MCM	400 MCM
2500	350 MCM	500 MCM
3000	400 MCM	600 MCM
4000	500 MCM	800 MCM
5000	700 MCM	1000 MCM
6000	800 MCM	1200 MCM

*See installation restrictions in Section 250-92(a).

(b) To Gas Pipes. The point of attachment of a grounding conductor to gas piping where permitted under Section 250-82, shall always be on the street side of the gas meter, and shall be accessible where practicable.

(c) To Other Electrodes. The grounding conductor shall be attached to other electrodes permitted in Sections 250-82 and 250-83 at a point which will assure a permanent ground. Where practicable the point of attachment shall be accessible.

250-113. Attachment to Circuits and Equipment. The grounding conductor, bond, or bonding jumper shall be attached to circuits, conduits, cabinets, equipment, and the like, which are to be grounded, by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections which depend upon solder shall not be used.

250-114. Continuity and Attachment of Branch Circuit Grounding Conductors to Boxes. Where more than one grounding conductor of a branch circuit enters a box, all such conductors shall be in good electrical contact with each other and the arrangement shall be such that the disconnection or removal of a receptacle, fixture, or other device fed from the box will not interfere with or interrupt the grounding continuity.

(a) Metallic Boxes. A connection shall be made between the one or more grounding conductors and a metallic box by means of a grounding screw which shall be used for no other purpose, or an approved grounding device.

(b) Nonmetallic Boxes. One or more grounding conductors brought into a nonmetallic outlet box shall be so arranged that a connection can be made to any fitting or device in that box which requires grounding.

250-115. Attachment to Electrodes. The grounding conductor shall be attached to the grounding electrode by means of (1) an approved bolted clamp of cast bronze or brass or of plain or malleable cast iron, or (2) a pipe fitting, or (3) other equally substantial approved means. The grounding conductor shall be attached to the grounding fitting by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections which depend upon solder shall not be used. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting, unless the clamp or fitting is of a type approved for such use.

250-116. Ground Clamps. For the grounding conductor of a wiring system the sheet-metal-strap type of ground clamp is not considered adequate unless the strap is attached to a rigid metal base which, when installed, is seated on the water pipe, or other electrode and the strap is of such material and dimensions that it is not liable to stretch during or after installation.

250-117. Protection of Attachment. Ground clamps or other fittings, unless approved for general use without protection, shall be protected from ordinary physical damage (1) by being placed where they are not liable to be damaged or (2) by being enclosed in metal, wood, or equivalent protective covering.

250-118. Clean Surfaces. Where a nonconductive protective coating, such as paint or enamel, is used on the equipment, conduit, couplings or fittings, such coating shall be removed from threads and other contact surfaces in order to insure a good electrical connection.

L. Instrument Transformers, Relays, etc.

250-121. Instrument Transformer Circuits. The secondary circuits of current and potential instrument transformers shall be grounded where the primary windings are connected to circuits of 300 volts or more to ground, and where on switchboards, shall be grounded irrespective of voltage, except that such circuits need not be grounded where the primary windings are connected to circuits of 750 volts or less and no live parts or wiring are exposed or accessible to other than qualified persons.

250-122. Instrument Transformer Cases. Cases or frames of instrument transformers shall be grounded where accessible to other than qualified persons, except that cases or frames of current transformers, the primaries of which are not over 150 volts to ground and which are used exclusively to supply current to meters, need not be grounded.

250-123. Cases of Instruments, Meters and Relays-Operating Voltage 750 or Less. Instruments, meters and relays which operate with windings or working parts at 750 volts or less shall be grounded as follows:

(a) **Not on Switchboards.** Instruments, meters, and relays not located on switchboards, which operate with windings or working parts at 300 volts or more to ground, and accessible to other than qualified persons, shall have the cases and other exposed metal parts grounded;

(b) **On Dead Front Switchboards.** Instruments, meters and relays (whether operated from current and potential transformers, or connected directly in the circuit) on switchboards having no live parts on the front of the panels shall have the cases grounded;

(c) **On Live Front Switchboards.** Instruments, meters and relays (whether operated from current and potential transformers, or connected directly in the circuit) on switchboards having exposed live parts on the front of panels shall not have their cases grounded. Mats of insulating rubber or other suitable floor insulation, shall be provided for the operator where the voltage to ground exceeds 150.

250-124. Cases of Instruments, Meters and Relays - Operating Voltage Over 750. Where instruments, meters and relays have current-carrying parts over 750 volts to ground, they shall be isolated by elevation or protected by suitable barriers, grounded metal or insulating covers or guards. Their cases shall not be grounded, except as follows:

(a) In electrostatic ground detectors the internal ground segments of the instrument are connected to the instrument case and grounded; the ground detector shall be isolated by elevation.

250-125. Instrument Grounding Conductor. The grounding conductor for secondary circuits of instrument transformers and for instrument cases shall not be smaller than No. 12 where of copper, or where of other metal shall have equal conductance. Cases of instrument transformers, instruments, meters and relays which are mounted directly on grounded metal surfaces of enclosures or grounded metal switchboard panels shall be considered to be grounded and no additional grounding conductor will be required.

M. Lightning Arresters

250-131. On Secondary Services, 750 Volts or Less. Where a lightning arrester is installed on a secondary service, the connections to the service conductors and to grounding conductor shall be as short as practicable. The grounding conductor may be (1) the grounded service conductor, or (2) the common grounding conductor, or (3) the service equipment grounding conductor. The bonding or grounding conductor shall be of copper not smaller than No. 14 or of equivalent corrosion-resistant material.

250-132. On Primary Circuits. The grounding conductor of a lightning arrester protecting a transformer which supplies a secondary distribution system may be interconnected as follows:

(a) **Metallic Interconnection.** A metallic interconnection may be made to the secondary neutral provided that, in addition to the direct grounding connection at the arrester:

(1) The grounded conductor of the secondary has elsewhere a grounding connection to a continuous metallic underground water piping system. However, in urban waterpipe areas where there are at least four waterpipe connections on the neutral and not less than four such connections in each mile of neutral, the metallic interconnection may be made to the secondary neutral with omission of the direct grounding connection at the arrester.

(2) The grounded conductor of the secondary system is part of a multigrounded neutral system, of which the primary neutral has at least four ground connections in each mile of line in addition to a ground at each service.

(b) Through Spark Gap. Where the secondary is not grounded as in Section 250-132(a), but is otherwise grounded as in Sections 250-82 and 250-83, such interconnection, where made, shall be through a spark gap having a 60-cycle breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kv, and there shall be at least one other ground on the grounded conductor of the secondary not less than 20 feet distant from the lightning arrester grounding electrode.

(c) By Special Permission. Except as above provided, interconnection of the arrester ground and the secondary neutral may be made only by special permission.